OUR BOOK SHELF

Manuals of Elementary Science—Crystallography. By H. P. Gurney, M.A. (Society for Promoting Christian Knowledge, 1878.)

THIS excellent little manual satisfies a want long felt, for, up to the present time, there was no book in which a general knowledge of the system of crystallography, first developed by Prof. Miller in his "Treatise on Crystallography," 1839, could be obtained. Prof. Miller's treatise and Tract are mainly occupied with the methods of calculation, and require a considerable knowledge of trigonometry. The manual before us aims at doing for these books what the crystyllographic introduction to Naumann's "Mineralogie" does for his "Lehrbuch der Krystallographie." It therefore avoids all the analysis used in the calculation of crystals, and limits itself to explaining the elementary geometrical principles involved in the representation of the faces by indices.

The method of development of systems of symmetry, rendered so familiar to us by Prof. Maskelyne, has been almost necessarily followed, and the author has consequently inverted the usual order of discussion of the different systems, beginning with the Anorthic, that of simplest symmetry, and proceeding through the different types of symmetry up to the cubic system, that of most complex symmetry. In the different systems the characteristic forms are shown to flow so simply from the conditions of symmetry that a moderately bright student ought to be able to deduce them himself after following Mr. Gurney's exposition in the first two or three systems. In his discussion of the rhombohedral system the author follows Prof. Miller. The hexagonal system, of which the rhombohedral is a hemisymmetrical development, is so imperfectly manifested by crystals that its discussion is only of theoretic interest and is unsuited to an elementary manual. In his discussion of merohedrism the author has not attended to the limiting condition, pointed out by von Lang, that the merohedral form should not be identical with the characteristic form of a system of lower symmetry, although here, likewise, he has the sanction of Prof. Miller's authority. The condition, however, is justified by the most recent observations, which have placed most of the minerals displaying such merohedrism in the systems of lower holohedral symmetry. We can heartily recommend the book to students even if they be able to study the more advanced text-books.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

On the Ancient Pitch of Organs

As I am obliged to intermit my researches on organ pitch for a few months, owing to pressure of other work, I wish to make a note of the point to which I have advanced, after consulting many old books, and actually measuring pitch and length of many old organ-pipes, for which I am obliged to the kind politeness of organ-builders, organists, and friends. When my researches are complete, they will appear with details in a paper to be read before the Society of Arts on the History of Musical Pitch, about a year hence. The delay arises from the difficulty of getting information from the Continent.

In England we have no organs older than the Restoration, 1660, as the Puritans smashed all church-organs in 1644-46.

The principle used by organ-builders was to make a certain pipe of the length of some multiple or easy sub-multiple of the standard length of measurement in their own country, and determine the other notes from its tone, according to the mean-tone or unequal temperament in universal use for organs everywhere till 1830, but beginning to be disused in France in 1834 and in England in 1854. There is an apparent exception in St. Jacobi Kirche at Hamburg, where equal temperament is claimed for 1720, when J. S. Bach played on that organ, and possibly in other old German organs. In England I have found the old unequal temperament still existing at St. George's Chapel, Windsor Castle, Kew Parish Church, St. Katherine's, Regent's Park, All Hallows the Great, Upper Thames Street, Maidstone Parish Church, St. Mary's, Shrewsbury, and several other organs which have been very recently re-tuned. The first equally tempered organ by Messrs. Gray and Davison was sent out in 1854.

The pitch note used from 1500 to 1650, at least in Germany, seems to have been F, for which a 13-foot pipe was employed for our F in the 16-foot octave. But the foot varied so much in Germany, being 3 per cent. longer than the English on the Rhine, and in Austria, and much shorter than the English in Central Germany, that the pitch thus determined varies by one to two equal semitones. The Brunswick foot, in 1620, where we have Prætorius's reference, possibly gave a tone of 35 vib. for the 13-foot pipe, an octave below the ordinary violoncello C.

In England Tomkyns (before the Commonwealth) fixes the F as 5 feet, which gives the A as 4 feet, and the double octave of this as 1 foot, and hence comes under the next category. The 13-foot F gives a 13-inch treble C, which, for Rhenish feet, would have a pitch of 425, whereas Handel's A was 423, having a pitch a minor third higher. This minor third constantly recurs. In Hamburg the St. Jacobi organ is a minor third sharper than the St. Michaelis organ, the first being a tone sharper and the latter a semitone flatter than French pitch. And strangest of all, the St. Jacobi organ had formerly one of its stops tuned to the low St. Michaelis pitch.

The old reason for fixing the pitch seems to have been to put the ecclesiastical tones within easy fingering for the organist, without using the chromatic notes (which *Arnold Schlick*, 1512, naïvely says is not convenient for most players), at the same time that they were within easy reach of a baritone voice. This is a point I have not yet worked out completely.

In England the foot-rule seems to have been generally adopted in early organs as the means of giving a standard, and it is not till about Green's time—a century ago—that I find it varied from this by a small fraction of an inch—not exceeding two-fifths.

The pitch of an open metal cylindrical flue-pipe used for the open diapason stop (but not "a show-pipe"), measuring 12 inches from the lower lip to the open end, varies from 472 to 475 vibrations in a second at 60° F. The variations are due to the size of the diameter, the force of wind, the opening at the foot, and the method of voicing. I have known such a pipe raised two vibrations in a moment by a slight alteration in voicing. This is the old standard pitch in England. Varieties depend upon the name of the note which it represents, and the classes of organs which I have met with in books or in reality, have hence been called by me the A foot, B flat foot, B foot and C foot organs.

1. The A foot organ has A 472 to 475. This was *Tomkyns's* pitch, as shown by Sir F. Gore Ouseley in his edition of "Orlando Gibbons," and seems to have been the pitch for which that composer wrote his Church music. It gives the mean tone C 565 to 570. As the French diapason normal is really A 435·875 (as determined originally by M. Cavaillé-Colt, and verified this year by Mr. Hipkins in Paris, by means of a Scheibler 440), this makes Tomkyns's pitch about three-quarters of a tone sharper than French pitch. This is the present existing pitch of St. Katherinen Kirche at Hamburg. The St. Jacobi organ, and also that in the Cathedral of St. Marie, at Lübeck, is a whole tone higher than French pitch. The great Franciscan organ at Vienna, 240 years old and untouched, gives A 460, which is only a semitone sharper than French pitch. These are the sharpest existing organs I have met with. The Franciscan organ is only used for the old ecclesiastical tone singing of the monks. This was also possibly the pitch recommended by *Prætorius* for church organs, the drawing in his book (1618) giving the B pipe one Saxon foot in length, with strong pressure of wind, and the Saxon foot being 7 per cent. shorter than the English.

It is as well to mention in passing that the tones and semitones here spoken of for measuring purposes, if not otherwise qualified, are *equal* semitones, and that, near enough for such purposes, an equal semitone and tone higher have 6 and $12\frac{1}{4}$ per cent. more vibrations, and thus a quarter and three-quarters of a tone higher have 3 and 9 vibrations more per cent. For unequal

or mean tone temperament, a *small* semitone has $4\frac{1}{2}$, a *large* one 7, and a tone 12 per cent. more vibrations. These numbers are very convenient for rough estimations.

The old French foot is 6 per cent. longer than the English, hence the one-foot pipe will be a semitone lower than the English, or about 443 to 446 vibrations. I have not met with a case of a French organ with A 443, or the one-foot pipe on A. But *Mersenne*, 1636, places the one-foot pipe on G, and this gives mean-tone A 496 and C 593. Now the St. Jacobi organ had actually A 491 and C 584 (equal temperament, making the C lower), as determined by forks tuned to the pitch and then measured. Hence, Mersenne's pitch, which even M. Cavaillé-Coll considered must be a mistake, actually exists at the present day.

2. The B flat foot organ, or B flat 472 to 475. This gives A 442, C 528, on the mean-tone temperament, that is, actually the pitch desired by the Society of Arts and not attained. This pitch was used by *Thomas Harris* in the Worcester Cathedral organ of 1666, by *Berhard Schmidt* (or Father Smith, as he has been called), in Durham Cathedral, 1683, Hampton Court, 1690, St. Paul's Cathedral, 1694-7, Trinity College, Cambridge, 1708, as I have ascertained, and probably in all his organs. It seems to have been occasionally used by the *Jordans*, who seem also to have built an A foot organ; but my inquiries are not yet complete. It is the favourite pitch of modern English organ builders, as I have ascertained by measuring the pitch-pipes of seven of the principal builders in London, which vary from C 524 to 528, at 60° F., to which all pitches are reduced.

3. The B foot organ, or B 472 to 475. This gives in England A 422 to 425, and C 506 to 512. This pitch was in general use, from at least 1700 to 1820, over England and over Germany. I found it in *Renatus Harris's*, All Hallows, Barking, 1675-7; St. Andrew Undershaft, 1696; and St. John's, Clerkenwell (date unknown); in *Harris and Byfield's*, St. Mary's, Shrewsbury; in *Byfield, Jordan, and Bridge's* two Great Yarmouth organs, 1733-40; in *Byfield and Green's*, St. Lawrence, Reading, 1771, and St. Mary's, Islington, 1772; in *Glyn and Parker's*, All Hallows the Great, Thames Street, 1749; in *Schnetzler's*, German Chapel Royal, St. James's Palace (date uncertain); in *Green's*, St. George's Chapel, Windsor, 1790; Winchester College Chapel, 1780; St. Katherine's, Regent's Park, 1778; and Kew Parish Church (date unknown). Glyn and Parker built the organ which Handel gave to the Foundling Hospital, 1750, and Handel, after conducting a performance of the "Messiah" there, in 1751, left his tuning-fork behind him. This fork is now in the possession of Rev. G. T. Driffield, Rector of Bow, and shows A 423, which is presumably the pitch of that organ. Mozart's clavier-maker, Stein, at Vienna, 1780-90, used a fork one vibration lower, A 422, which was undoubtedly the pitch of Haydn and Beethoven, and hence of Church music generally. It is a quarter of a tone flatter than French pitch. This was the pitch used when the Philharmonic Society was started in London, 1813, and was retained to 1826. Silbermann's organ at the Roman Catholic Church, Dresden, was about a comma flatter, or A 415.

4. The C foot-organ, or C 472 to 475 and A 495. The only instance known to me in England is Trinity College, Cambridge, as recorded in 1759 by the celebrated Dr. Robert Smith, its master, in his "Harmonics." But this was after its pitch (which was originally that of a B flat foot-organ) had been lowered a mean tone, by shifting the pipes, which, as he tells us, made it agree with the Roman pitch-pipes of 1702. But the French foot being a semitone flatter than the English, the Versailles B foot-organ (1786) had a pitch of A 396, C 474, as shown by the fork preserved in the Conservatoire in Paris, and hence precisely agreed with the altered Trinity College organ and the Roman pitch-pipe. Delezenne, in 1854, was fortunate enough to find an old dilapidated organ at the Hospice Comtesse, near Lille, which gave C 448, as near as he could measure, agreeing well with C 443, the calculated pitch of the French C foot organ.

This seems to be the first attempt at systematically finding the pitch of organs. The pitch of the pipes was in all cases found, when they could be actually heard, by beats with tuning-forks made for me, to the extent of an octave, on the basis of Scheibler's 256, 435, 440 (which I have reason to believe perfectly accurate), by Valantine and Carr, 76, Milton Street, Sheffield, and I have also reason to believe that these latter forks are not more than half a vibration wrong with Scheibler in any case. But before my complete paper is ready I shall have verified them by eighteen other forks of Scheibler now being very carefully copied at Crefeld. To hear the beats I stand thirty or forty feet away from the organ, and hold the fork over a resonance jar tuned to its pitch by pouring in water. The bellows is first filled, and no pumping is allowed during the ten seconds that I count. The beats are beautifully distinct, and I consider the result to be correct within one-fifth of a vibration.

The correction for temperature, which is most important (as at C 500 it is more than half a vibration per degree Fahr., to be added for higher and subtracted for lower temperature), is found by the following rule:—Add four per cent. to the number of vibrations observed, divide result by 1,000, and multiply by the number of degrees required. I have thus harmonised measurements made between 73° and 45° F.

The rule for finding pitch from measurement was given by M. Cavaillé-Coll (*Comptes Rendus*, 1860, p. 176), and, reduced to English measures, is as follows:—

Let L be the length, in English inches, of an open flue cylindrical metal diapason from the lower lip to the open end, and D its internal diameter, also in inches. The latter measure is frequently difficult to make, on account of the jagged, or "coned," or compressed, extremity. Then use the outer circumference, by wrapping a piece of paper round the pipe where it is truly circular; calculate the diameter as $\frac{7}{22}$ circumference, and throw off $\frac{1}{25}$ inch for the thickness of the pipe, to find D, which has to be known with considerable accuracy.

Let V be the number of double vibrations in the pipe, at 60° F., then

$$V = \frac{20080}{3L + 5V}.$$

I tried this formula with a whole octave of pipes at Green's St. Katherine's organ, and found that the error rarely reached one comma (or 1 in 80), which many persons can't hear, and never reached two commas (or 1 in 40). Since a quarter of a tone is 3 per cent. (or 1 in $33\frac{1}{3}$), and a semitone is 6 per cent. (or 1 in $16\frac{2}{3}$), this gives a far better knowledge than we can obtain by ordinary estimation of ear, without counting beats by measured forks.

It would confer a great favour on me if any one could give me these dimensions of old, unaltered organ pipes for the pipe which is nearest to twelve English inches in length, anywhere, especially abroad, naming the place and the note, and, if possible, date and builder, or would point out any existing unaltered old organs.

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The Formation of Mountains

MR. ALFRED R. WALLACE asks one of our "great" physicists to enlighten us about the possibility of the interior of the globe "cooling more rapidly than the crust." If he will turn to a chapter on Conduction in such a work as Maxwell's "Theory of Heat," he will find an explanation of the principle. At p. 247 is a passage especially relating to the loss of heat by the earth.

But perhaps even a little physicist may help our great naturalist as the mouse did the lion.

In the first place it is of course understood that whenever it is said that "the interior of the globe cools more than the crust," it is not meant that it ever becomes cooler than the crust, but only that the interior, from age to age, goes on getting cooler than it was before, whilst the crust keeps at nearly a constant temperature.

An illustration, which I think gives a good idea of this process, may be taken from the dispersion of a crowd of persons in the street. Suppose each person to represent a certain quantity of heat. Then the number of persons in any space may be considered to represent its temperature, so that the crowded part will represent a very hot space. As the people disperse they move off the more quickly the further they get from the dense mass.

Now draw two lines near together across the street at some small distance from the densest part of the crowd, and let the space between these two lines represent the crust of the earth, while the space occupied by the crowd represents the earth's interior, and all beyond the outer line represents infinite space. Then the number of people passing outwards between the two lines at any particular moment will represent the quantity of heat in, and so the temperature of, the crust. At the